

Kazuko M. EMURA (HASEGAWA)*: **A cytotaxonomical study
on the Eurasiatic species of the genus *Cimicifuga* (1)**

江村 (長谷川) 一子*: ユーラシア産サラシナシ ヨウマ属の
細胞分類学的研究 (1)

The genus *Cimicifuga* L. (Ranunculaceae) is widely distributed in the northern hemisphere, but it is absent from the Arctic region, the tropics and the southern hemisphere. About 11 species have been known, the distribution of each species being very limited, and in Eurasia are found 6 species, *C. foetida* L., *C. simplex* Wormsk., *C. heracleifolia* Komarov, *C. dahurica* Maxim., *C. acerina* (S. & Z.) Tanaka, and *C. japonica* (Thunb.) Sprengel. *C. foetida* is most widely distributed in Eurasia, and *C. simplex*, *C. dahurica*, and *C. acerina* are also spread considerably widely, but *C. heracleifolia* and *C. japonica* are in very limited areas. In North America, *C. racemosa* Nutt., *C. americana* Michx., and *C. cordifolia* Pursh occur in the eastern part of the U.S.A. and south-eastern Canada, and *C. elata* Nutt. and *C. laciniata* S. Wats. in the north-western part of the U.S.A.

A world monograph of the genus *Cimicifuga* was published in 1893 by E. Huth and he divided the genus into two groups. The Eurasiatic species were studied by many authors; Hooker, J.D. 1875 (Himalaya), Makino, T. 1897 (Japan), Finet, A. & Gagnepain, F. 1904 (China), Komarov, V.L. 1904 & '37 (Manchuria, Russia), Hegi, G. 1912 (Europe), Nakai, T. 1916 (Japan), Hulten, E. 1928 (Kamchatka), Koidzumi, G. 1930 (Japan, China), Handel-Mazzetti, H. 1931 (China), Hara, H. 1943 (Japan), Tamura, M. 1960 (Eurasia), etc. Cytological studies of *Cimicifuga* were made by Lewitsky, G.A. 1931, Langlet, O. 1932, Nakajima, G. 1933, Sugiura, T. 1937 and Gregory, W.C. 1941. Recently the Japanese species including some varieties were cytologically investigated by Kurita, M. 1956, '57, '58, '59, '61.

In the present study, the author tried to define the features of each species cytotaxonomically excepting for *C. foetida* which was previously

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reported by the present author (1969 & 70). The morphology of the follicles, seeds, and petals which had been the most important characters of this genus were reexamined, and the phyletic relations among these species were suggested. Especially about the Japanese species, the variations of each species were cytogeographically studied based on abundant living plants.

Materials and methods

Morphological and distributional data were obtained from living plants which have been collected from many places in Japan and four places in Korea as well as from herbarium specimens and literatures. *C. acerina* was studied by 23 collections from the wild, *C. japonica* 11 collections, and *C. simplex* 45 collections all from the wild. Voucher specimens of the living materials used in this study are preserved in the Herbarium of the University of Tokyo (TI). About five hundreds specimens from the five herbaria listed below have been examined.

Gray Herbarium of Harvard University. (GH)

The Herbarium of the University of Tokyo. (TI)

The Herbarium of the Kyoto University. (KYO)

The Herbarium of the National Science Museum. (TNS)

The Herbarium of the Kanazawa University. (KAN)

The cytological technique applied in this study is the oxyquinoline aceto-orcein squash method described in my previous report of Journ. Jap. Bot. 43: 141-155.

Cimicifuga L., Syst. Nat. ed. 12: 659 (1767).

Herbaceous perennial. Stem erect 50-200 cm tall, slightly striated, glabrous or pubescent. Leaves ternate, biternate, triternate, or pinnate-ternate; leaflets glabrous or pubescent, ovate or narrowly-ovate, 1-3 lobed or palmately lobed, sharply serrate on the margin, cordate or shortly attenuate at the base, and acute at the apex. Inflorescence an elongate terminal raceme with many flowers; flowers pedicellate or sessile. Sepals (2-) 4-6 in a flower, obovate, creamy white, 2-4 mm long, caducous. Petals 2-3 in a flower, creamy white, the apex entire or bilobed (excepting for *C. elata* without petals). Stamens numerous; filaments filiform, elongate, 3-3.5 mm long; anthers broad elliptic, 0.3-0.5 mm long, yellowish. Carpels 1-7 (-8), the

mature follicles oblong or rectangular, 10-15 (-20) mm long, stipitate, style short or elongate, straight or hooked. Seeds 5-15 per follicle, oblong, 2.5-3.5 mm long, smooth or chaffy with wings on both sides. Pollen grains 3-colpate or 6-polyrugate, the surface subreticulate, $(20-)\text{22-35}\mu \times (18-)\text{20-30}(-33)\mu$.

Type species: *C. foetida* L.

Morphology of follicles, seeds and petals

The two types of follicles and seeds are found in the genus *Cimicifuga*. The follicle in one type is only one or rarely two in a flower, oblong, and the style is short, thick and straight. The follicle of this type has always the same type of seeds, horizontal in a double row with smooth close coat, like a segment of orange. *C. acerina*, *C. japonica*, *C. racemosa*, and *C. elata* have the follicles and the seeds of this type. Huth, E. separated these four species as *Eucimicifuga* from all the other species. The follicle of the other type is also oblong or rectangular, and three to five (rarely eight) in a flower, but the style is elongate and sometimes hooked or curled. The latter type of follicle has always the seeds different from the former, and they are oblong and flattened, covered with chaffy wings on both sides. The two types of the seeds seem to be very different from each other, but it was found that, in the younger stage, both of two are almost similar, and transform gradually changed each other. In the youngest stage, both of the two seeds are the miniatures of the former type (Fig. 1), the segment of orange, and the cross sections are fan-shaped. The former seeds grow larger, covered with the smooth close coat, but the shape is unchanged (Fig. 1, A). On the other hand, the latter seeds grow larger, and the delicate thin wings are born on the double rows (Fig. 1, B2). The seeds become flatter and flatter, and the wings become larger; the cross section of this seeds are oblong with the close chaffy coat (Fig. 1, B4). The arrangement of the seeds in the follicle is shown in Fig. 2. In the youngest stage, both of the two seeds are arranged in two rows; in the mature follicles, the arrangement of the former seeds is as same as the younger stage (Fig. 2, A & B), but the latter seeds changed flattish, and also in two rows slightly slip out each other (Fig. 2, C & D). The number of the seeds in a follicle is

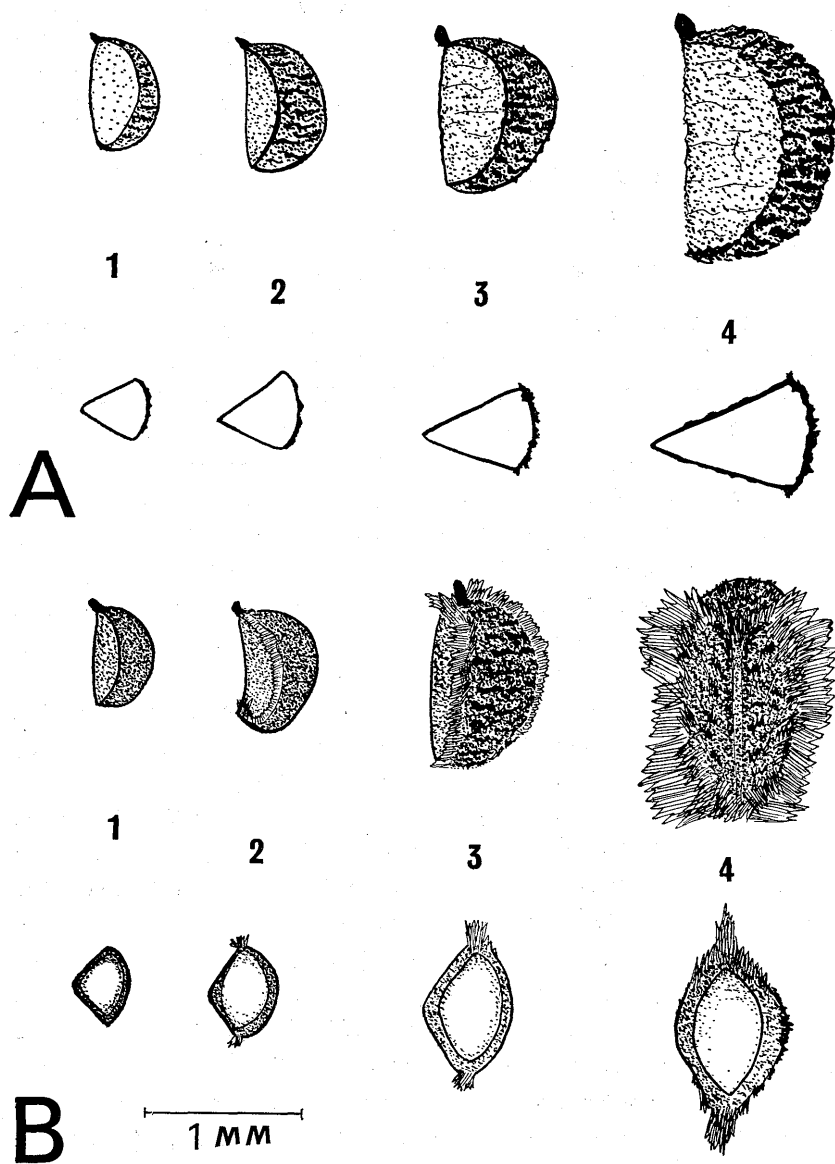


Fig. 1. The processes of the growth of seeds. A. *C. acerina*. B. *C. simplex*.

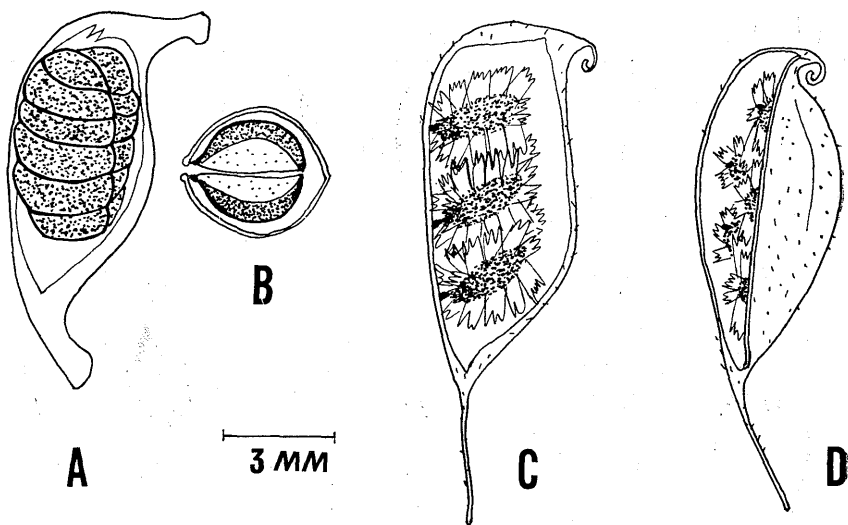


Fig. 2. The arrangement of seeds in a follicle. A & B. *C. acerina*. A. Seeds arranged in two rows. B. Cross section of the follicle. C & D. *C. simplex*. C. The arrangement of seeds seen from one side of a follicle. D. Seeds in two rows slightly slip out each other.

10-15 in the former type, and 5-8 in the latter type.

The shape of petals are very various, but the basal concave nectary is the common character through all the Eurasiatic and American species, excepting for *C. racemosa* without a nectary and *C. elata* without petals. Usually, the petal of *Cimicifuga* is slightly smaller than the sepal, ovate, and the apex is one-lobed or bilobed. Those of *C. japonica*, and *C. acerina* are always one-lobed and the apex is thinner, much resembling the sepals (Fig. 3, A). *C. simplex* of Japan rarely has the petals similar to those of *C. japonica* or *C. acerina*, but usually bilobed, and the two lobes are long and thinner (Fig. 3, B). The petals of *C. simplex* in Manchuria and Korea, and *C. heracleifolia* are also one-lobed or bilobed, but the apices are thicker and the lobes are small (Fig. 3, C & D). The petals of *C. foetida* are most variable; those in Altai are one-lobed and thinner, very similar to the sepals (Fig. 3, E); those in Korea, Manchuria, China (Yunnan), and Europe, are one-lobed or bilobed and the apices are thick, very similar to the petals of *C. simplex* in Korea and Manchuria; in some places of Yunnan and Himalayas, the apices of bilobed petals are somewhat globular, and these petals

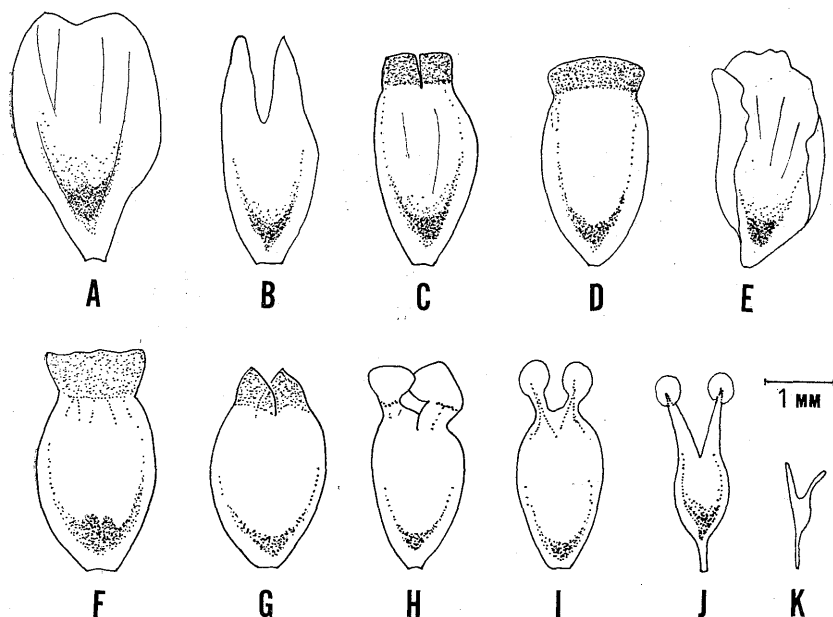


Fig. 3. Petals of *Cimicifuga*. A. *C. japonica*. B. *C. simplex* (Japan). C & D. *C. simplex* (Korea). E. *C. foetida* (Altai). F, G & I. *C. foetida* (Yunnan). H. *C. foetida* (Bhutan). J. *C. dahurica*. K. *C. racemosa*.

resemble those of *C. dahurica* (Fig. 3, H & I). *C. americana*, *C. cordifolia* and *C. laciniata* have also the bilobed petals, but *C. elata* has no petal. The petals of *C. racemosa* are bilobed and the apices are thinner like that of Japanese *C. simplex*, but the size of the petals is 1/8-1/10 smaller than the sepal (Fig. 3, K). The petals of *C. dahurica* are different from the other species; they are acutely bilobed and have the anther-like vacant apices on each lobe, and were described as staminodium by Huth, E. (Fig. 3, J). As described above, the petals of the genus *Cimicifuga* are considered to be unstable and variable.

Among the Eurasiatic species, the floral structures of *C. japonica*, and *C. acerina* may be more primitive, and the other species such as *C. foetida* etc. may be further evolved because the number of the carpels in one flower increases and the seeds are got flattened as described above. The floral structure of *C. dahurica* may be the most evolved, because the number of

the carpels more increases (five to eight), the petals are especially specialized, and the plants are almost dioecious.

Key to Eurasiatic species

- A. Follicle one (rarely two) per flower, with a short and straight style.
Seeds horizontal in a double row with smooth close coat. Flowers hermaphrodite. Pollen grains 6-polyrugate. (Sect. Pityrosperma)B.
- B. Upper surface of leaflet pubescent on the midrib and lateral veins.
..... *C. japonica*
- B. Upper surface of leaflet pubescent in the submarginal part
..... *C. acerina*
- A. Follicle three to five (rarely eight) per flower, with an elongate and hooked style. Seeds oblong and flat, with chaffy wings on both sides. Pollen grains 3-colpate. (Sect. Cimicifuga).....C.
- C. Flowers hermaphrodite (rarely dioecious), petals without anther-like apex D.
- D. Leaves tri- or pinnate-ternate, leaflet ovate or narrowly ovate, 3-5(-8) cm longE.
- E. Inflorescence with many lateral branches.....*C. foetida*
- E. Inflorescence simple or with a few lateral branches
..... *C. simplex*
- D. Leaves bi-ternate, leaflet broad ovate, 10-20(-25) cm long.
..... *C. heracleifolia*
- C. Flowers dioecious (rarely hermaphrodite), petals with two anther-like apices*C. dahurica*

1. *C. japonica* (Thunb.) Sprengel, Syst. Veg. 2: 628 (1825).

Stem 50-100 cm tall. Leaves ternate or biternate; leaflets ovate, 3-10 cm long, palmately incised and serrate on the margin, cordate at the base, acute at the apex, the upper surface pubescent on the midrib and lateral veins. Inflorescence a lax and elongate terminal raceme with shorter lateral ones. Flowers sessile; sepals 4, ovate, glabrous; petals obovate, 3.5-4 mm long, entire. Carpel one (rarely two) per flower, mature follicle oblong, 7-8 mm long with a short stipe, style short and straight. Seeds horizontal in a double row with smooth close coat. Distr.: Japan (middle part of Honshu).

var. **acutiloba** Hara in Act. Phytotax. Geobot. 13: 200 (1943).

Leaflet deeply palmate, acuminate at the apex. Distr.: Japan (Kii Peninsula).

2. **C. acerina** (Sieb. et Zucc.) Tanaka in Bult. Sci. Fac. Terk. Kyushu Imp. Univ. 1: 203, 208. (1925).

Stem 50–100 cm tall, sparsely pubescent. Leaves ternate, rarely biternate; leaflets palmately lobed, deeply incised on the margin, 5–10 cm long, acute at the apex, cordate at the base, the upper surface pubescent in the submarginal part. Inflorescence a lax and terminal raceme with shorter lateral ones. Flowers sessile; sepals four, ovate, glabrous; petals obovate, 3.5–4 mm long, entire. Carpel one (rarely two) per flower, mature follicle oblong, 7–8 mm long with a short stipe, style short and straight. Seeds horizontal in a double row with smooth close coat. Distr.: Japan (Kyushu), Korea, China.

var. **intermedia** Hara in Act. Phytotax. Geobot. 13: 200–201 (1943).

Leaflet thicker, 10–15 cm long. Distr.: Japan (Shikoku, Chugoku region, Kyushu).

var. **macrophylla** (Koidz.) Hara in Act. Phytotax. Geobot. 13: 201 (1943).

Leaflet ovate, large 10–25 (–30) cm long, thicker, not palmately lobed, shallowly incised on the margin, cordate at the base. Distr.: Japan (Honshu, Shikoku, Kyushu).

var. **peltata** (Makino) Hara in Act. Phytotax. Geobot. 13: 201 (1943).

Leaflet ovate, large 10–25 (–30) cm long, thicker, not palmately lobed, shallowly incised on the margin, peltate at the base. Distr.: Japan (middle part of Honshu).

3. **C. foetida** L. Syst. Nat. ed. 12: 659 (1967).

I have already described in detail about this species in Journ. Jap. Bot. 44: 76–84 (1969).

4. **C. simplex** Wormsk. in DC., Prodr. 1: 64 (1824).

Stem 100–200 cm tall, glabrous or pubescent. Leaves tri-ternate, rarely pinnate-ternate; leaflet glabrous or pubescent, ovate or narrowly ovate, 3–10 cm long, 1–5 cm wide. Inflorescence without lateral branches or with a few shorter branches, densely flowered. Flowers pedicellate, with pedicel 5–10 (–15) mm long; sepals 4–6 per flower, pubescent, 3–4 mm long; petals ovate, 2.5–3 mm long, the apex entire or bilobed. Carpels 3–4 per flower, mature follicles oblong 10–15 (–20) mm long, with a stipe 2–3 mm long, pubes-

cent, style elongate and hooked or curled. Seeds oblong with chaffy wings. Distr.: Japan, Korea, Manchuria, Mongolia, S.E. Siberia, Saghalien, Kurile Islands, Kamchatca.

5. *C. heracleifolia* Komarov in Acta Hort. Petrop. 18: 438 (1901).

Stem 60–100 cm long, glabrous. Leaves biternate; leaflet glabrous, broad ovate, 10–20(–25) cm long. Inflorescence a very lax, elongate terminal raceme with a few shorter lateral ones. Flowers pedicellate; sepals 4 per flower, glabrous, 2–2.5 mm long; petals ovate, entire or bilobed, 2.5–3 mm long. Carpels 2–3, mature follicles ovate, 10–15 mm long with a stipe, pubescent, style elongate and hooked or curled. Seeds with chaffy wings on both sides. Distr.: Korea, S. Manchuria.

6. *C. dahurica* (Turcz.) Maxim., Prim. Fl. Amur.: 28 (1859).

Stem 100–150 cm tall, densely pubescent. Leaves tri-ternate; leaflet broad ovate, 7–15 cm long. Inflorescence well branched; flowers usually dioecious, rarely hermaphrodite, pedicellate; sepals 5 per flower, outer two sepals usually pubescent, 2.5–3 mm long; petals two-horned, with the anther-like apex on each horn, 2–2.5 mm long and 1–1.5 mm wide. Female plant: Carpels 5–8 per flower, the head of mature follicle oblong or square, 10–15 mm long with a stipe; style elongate and hooked. Seeds with chaffy wings on both sides. Many abortive stamens (staminodia) inside the petals, cylindrical, 2–2.5 mm long. Male plant: Stamens numerous, without abortive stamens and carpels. Distr.: Korea, Manchuria, Dahuria.

**Cytogeographical research on the genus *Cimicifuga*
in Asia especially Japan**

The chromosome numbers of all the *Cimicifuga* are $2n = 16$ (diploid), excepting for Himalayan *C. foetida* already described to be $2n = 32$ (tetraploid) by the present author, and the karyotypes are very similar to each other, and they are expressed in the following formula: $2n = 16 = 10V + 4J + 2I$.

The presence or absence of secondary constriction or satellite is different in each species. I wish to describe the Asiatic species especially the Japanese ones cytogeographically.





10 μ

Table 1. The chromosome numbers of the Eurasiatic species of *Cimicifuga*.

Species	n	2n	Author	Date
<i>C. acerina</i> var. <i>acerina</i>		16	Emura (Hasegawa)	Unpublished
var. <i>intermedia</i>		16	Kurita	1957
		16	Emura (Hasegawa)	Unpublished
var. <i>macrophylla</i>		16	Kurita	1957
		16	Emura (Hasegawa)	Unpublished
var. <i>peltata</i>		16	Kurita	1957
		16	Emura (Hasegawa)	Unpublished
var. <i>obtusiloba</i>	8		Sugiura	1937
<i>C. dahurica</i>		16	Langlet	1932
		16	Emura (Hasegawa)	Unpublished
<i>C. foetida</i> L.		16	Lewitsky	1931
		32	Emura (Hasegawa)	1969
	8, 16	16	Emura (Hasegawa)	1970
<i>C. foetida</i> (<i>C. simplex</i> ?)		16	Nakajima	1933
<i>C. heracleifolia</i>		16	Emura (Hasegawa)	Unpublished
<i>C. japonica</i> (<i>C. acerina</i> ?)		16	Langlet	1932
<i>C. japonica</i> var. <i>japonica</i>		16	Kurita	1957
		16	Emura (Hasegawa)	Unpublished
var. <i>acutiloba</i>		16	Emura (Hasegawa)	Unpublished
<i>C. simplex</i> (<i>C. foetida</i>)		16	Langlet	1932
<i>C. simplex</i>		16	Emura (Hasegawa)	Unpublished
var. <i>ramosa</i>		16	Kurita	1957
var. <i>yezoense</i>		16	Kurita	1959

(To be continued)

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和文要約は後編でまとめて述べる。

Fig. 4. Somatic chromosomes of *Cimicifuga*. 1. *C. japonica* var. *japonica* (Mt. Bukô). 2. *C. japonica* var. *acutiloba* (Kitayama). 3. *C. acerina* var. *acerina* (Mt. Unzen). 4. *C. acerina* var. *intermedia* (Mt. Ishidate). 5. *C. acerina* var. *macrophylla* (Mt. Tanzawa). 6. *C. acerina* var. *peltata* (Takasu). 7. *C. dahurica* (Kwangnung). 8. *C. heracleifolia* (Kwangnung).

Fig. 5. Karyograms of somatic chromosomes reproduced from Fig. 4. 1. *C. japonica* var. *japonica*. 2. *C. japonica* var. *acutiloba*. 3. *C. acerina* var. *acerina*. 4. *C. acerina* var. *intermedia*. 5. *C. acerina* var. *macrophylla*. 6. *C. acerina* var. *peltata*. 7. *C. dahurica*. 8. *C. heracleifolia*.